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CENTRAL INTELLIGENCE AGENCY
WASHINGTON 25, D. C.

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IRONBARK

22 MAY 1962

MEMORANDUM FOR: The Director of Central Intelligence

SUBJECT : STRATEGIC MISSILE BULLETIN: "The Selection of Aiming Points in Firings of Ballistic Missiles at Heterogeneous Targets"

1. Enclosed is a verbatim translation of an article which appeared in a Soviet Ministry of Defense publication called Information Bulletin of the Missile Troops (Informatsionyy Byulleten Raketnykh Voysk). This publication is classified TOP SECRET by the Soviets and was first issued in 1961. It is intended for generals and officers of the Missile Troops.

2. For convenience of reference by USIB agencies, the codeword [redacted] has been assigned to this series of TOP SECRET [redacted] reports containing documentary Soviet material. The word [redacted] is classified [redacted] and is to be used only among persons authorized to read and handle this material. 50X1-HUM 50X1-HUM 50X1-HUM

3. In the interests of protecting our source, [redacted] should be handled on a need-to-know basis within your office. Requests for extra copies of this report or for utilization of any part of this document in any other form should be addressed to the originating office. 50X1-HUM

Richard Helms

Richard Helms
Deputy Director (Plans)

Enclosure

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Original: The Director of Central Intelligence

cc: Military Representative of the President

Special Assistant to the President for National Security Affairs

The Director of Intelligence and Research, Department of State

The Director, Defense Intelligence Agency

The Director for Intelligence, The Joint Staff

The Assistant Chief of Staff for Intelligence, Department of the Army

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CSDB-3/649,987

COUNTRY : USSR

SUBJECT : STRATEGIC MISSILE BULLETIN: "The Selection of Aiming Points in Firings of Ballistic Missiles at Heterogeneous Targets"

DATE OF INFO : September 1961

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Following is a verbatim translation of an article titled "The Selection of Aiming Points in Firings of Ballistic Missiles at Heterogeneous Targets", which appeared in the 1961 Second Issue of a TOP SECRET Soviet publication titled Information Bulletin of the Missile Troops (Informatsionnyy Byulleten Raketnykh Voysk). The 1961 Second Issue was sent to press on 19 September 1961.

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The Selection of Aiming Points in Firings of Ballistic Missiles at Heterogeneous Targets

Since the position of the aiming point (tochka pritselivaniya) influences the result of a firing to a significant degree, the selection of aiming points is a very important task in the planning of a missile firing. By aiming point is meant the point for which data are prepared for missile launchings. Not only is the expected result diminished if the aiming point (points) is incorrectly calculated, but the assigned degree of target destruction may not be achieved, although the yield of the charge (charges) is adequate.

Precise solution of the task of choosing aiming points is complicated and can be achieved with the help of electronic computers (elektronno - vychislitelnaya mashina). At the same time it is possible to use methods of approximation in the selection of aiming points which permit the rapid and simple determination of a location which is close to the optimum and to guarantee a solution of the problem under examination with an accuracy which is sufficient in practice.

The method of selecting aiming points depends on the nature of the target. All strategic targets can be divided into two main groups, according to their makeup.

The first group includes such targets as political-administrative centers, many military industrial areas, troop disposition areas, and others. The characteristic peculiar to this group is that the separate elements which constitute the target (buildings, technical structures, etc.) are uniformly disposed throughout the whole territory of the target and are approximately similar in their essential features. Such targets are generally known as area targets (ploshchadnyy).

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The second group consists of grouped heterogeneous (gruppovoy raznorodnyy) targets. To these belong means of nuclear attack (missile and aviation bases), some military industrial areas and others. These targets consist of a limited number of independent objectives (elements), dispersed at random throughout the area of the target and differing both in their essential characteristics and in importance.

The task of selecting aiming points for firings against targets in the second group is most complicated, since in this case it is necessary to consider not only the mutual disposition of the installations which make up the target, but also their differing vulnerability to the effects of the damaging factors of a burst. In the present article, the solution of this problem by the method of approximation is studied. The selection of aiming points for area targets is set out in the firing rules.

In choosing aiming points, one should start from the reliance put upon the fulfilment of the fire mission which is being planned and from the requirement to ensure maximum economy of firings. As a reliability characteristic of the performance of a fire mission, we take the probability of destruction of the target--P, and as the characteristic of economy of launchings-- an indicator of economy of using charges (zaryad)--W, determined by the formula

$$W = \frac{M[\xi]}{\xi_{max}}, \qquad (1)$$

where $M[\xi]$ is the mathematical expectancy of damage inflicted on the target; ξ_{max} - the maximum possible damage for the given target.

From formula (1) it is clear that the greatest economy of firings will be effected in a case when the mathematical expectancy of damage inflicted on the target is $M[\xi]$ or, which is the same thing, where the mathematical expectancy of the relatively destroyed part of the target--M, reaches

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maximum value. Here we will bear in mind that the relatively destroyed portion of a target is expressed in percentages of the total number of elements (installations) which make up the target.

The probability of destroying a group target P can be linked with the probability of destroying each individual element of the target P_i. In carrying out the task it is necessary to begin by ensuring the requisite destruction probability of each separate target element. The question of determining this probability, which proceeds from the degree of reliance on the performance of a fire mission will be reviewed below. For the time being we will assume that we have the value of the requisite destruction probability for each separate element of the target. The task of selecting an aiming point (points) can then be formulated as follows:

Given are: the target, the trotyl equivalent of the nuclear charge, the range ($\overline{Vd}$) and lateral ($\overline{Vb}$) dispersion probabilities, and the required destruction probability of each element (installation) of the target. Determination of the aiming point (or points, in the case of several firings) proceeds from the fulfilment of two conditions:

1. The probability of destroying each element must be no less than that required (trebuyemaya), $P_i \geqslant P_{i\ \underline{tr}}$;

2. The mathematical expectancy of the relatively destroyed portion of the target must be the maximum, M = M max.

For the solution of this problem a graphic method, the substance of which follows, is proposed. By graphic layout of the target plan an area is found, in which each point, if selected as an aiming point, ensures that the probability of destruction of each element of the target is not less than that required (the first condition). Then, a point is taken within the area which has been chosen, which

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ensures the fulfilment of the second condition - that is, which provides the maximum value of mathematical expectancy of the destroyed portion of the target. This point is taken as the aiming point.

Let us examine the principle of graphic layout.

The probability of destroying an i-th element of a target is defined as the probability of hitting points within the limits of the zone of destruction. It depends on the range and lateral dispersion characteristics, on the radius of the zone of destruction for the i-th element $R_{a\,i}$ and on the displacement of the aiming point $\underline{Ts}$ in relation to the i-th element to r_i (Figure 1). The elliptical dispersion for ballistic missiles can be replaced without great inaccuracies by a circle with the characteristics

$$\underline{Vp} = \frac{Vd + Vb}{2}.$$

Then the probability of destroying an i-th element P_i depends on the three values $R_{a\,i}$, $\underline{Vp}$ and r_i. If we know P_i, $\underline{Vp}$ and $R_{a\,i}$, we can determine r_i--that is, the maximum distance between the aiming point and the target element in which we will still have the necessary value of target destruction probability.

Clearly, if a circle with a radius r_i is drawn from the center of the target element, we have an area within which the destruction probability of a target element P_i for any point is not less than that required, i.e., we have an area in which the first condition for the i-th element is fulfilled:

$$P_i \gg P_{i\ \underline{tr}};$$

if r_i was determined from the required destruction probability of the target element.

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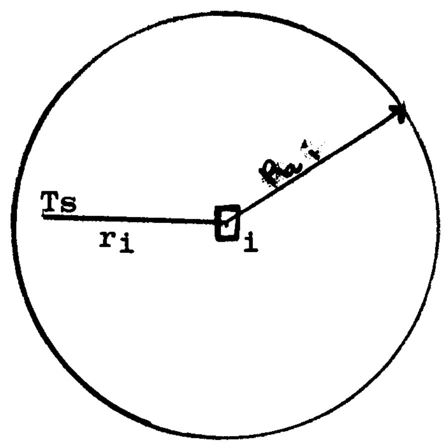

Figure 1

Having determined r_i for each target element and having drawn on the target plan appropriate circles from the center of each element, then in the space overlapped by all the circles we get an area in which the first condition is met for all the target elements. In Figure 2, examples of such a layout are shown for targets which consist of two, three and four elements (we get a similar picture for a large number of elements).

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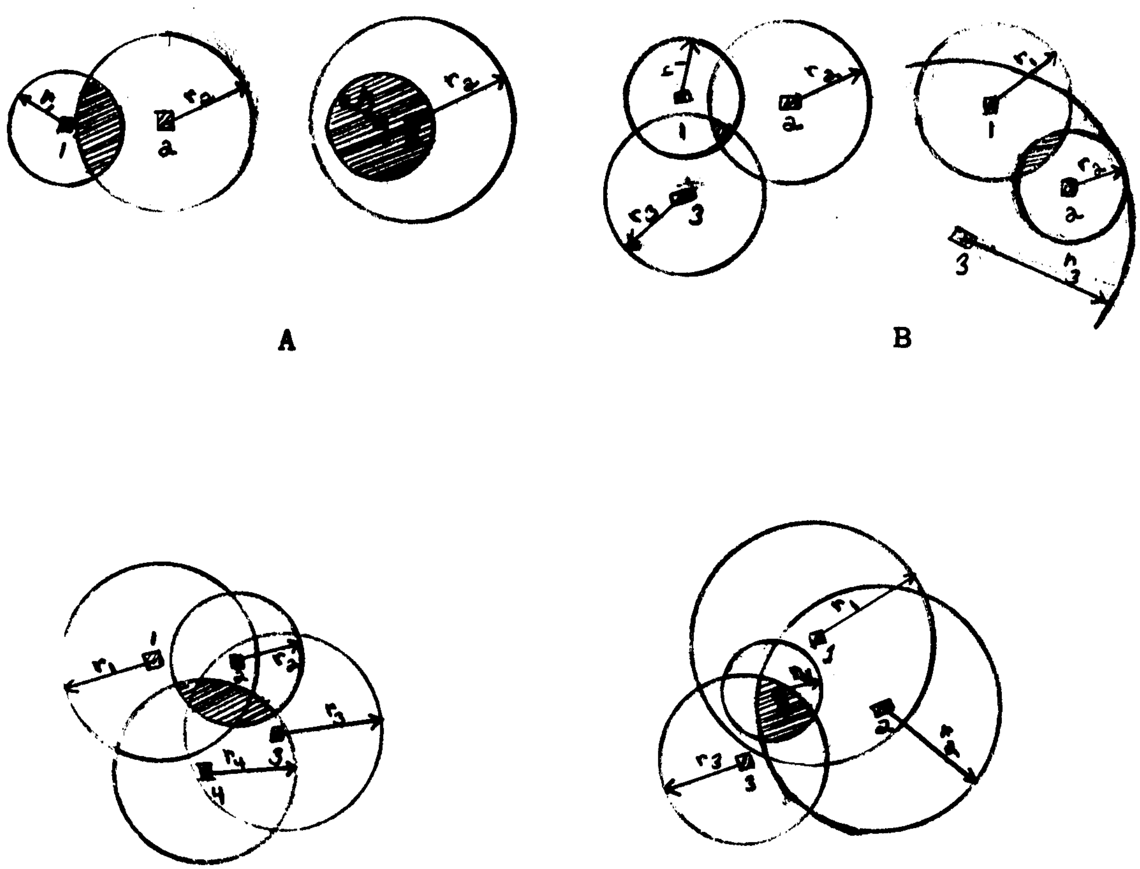

A B

C

Figure 2

Specific conditions may produce a case in which a common area is not formed for all elements. This means that in launching a single missile with a charge of a given trotyl equivalent, the assigned degree of destruction is not ensured. Consequently, it is necessary either to increase the yield of the charge, or to plan on firing several missiles. In the latter case, the necessary quantity of missiles must be determined. For this purpose all target elements are divided into the minimum number of groups, in such a way that for each group there is a single common area of possible aiming points. The expenditure of missiles is fixed in accordance with the number of such groups. Aiming points in this case are selected for each separate group of elements in accordance with the expenditure of missiles.

Examples of targets which consist of three and four elements are shown in Figure 3. Clearly, in the cases which are represented in Figure 3a and 3b, two missiles are needed, and in 3c, three missiles. A similar situation can occur when the target is made up of a large number of elements (installations). However, it should be noted that, in practice, the number of groups of elements and, hence, the expenditure of missiles, will not exceed two or three, with a maximum of four, because the radii of the zones of destruction are large and differ only insignificantly from the possible distances between the different target elements.

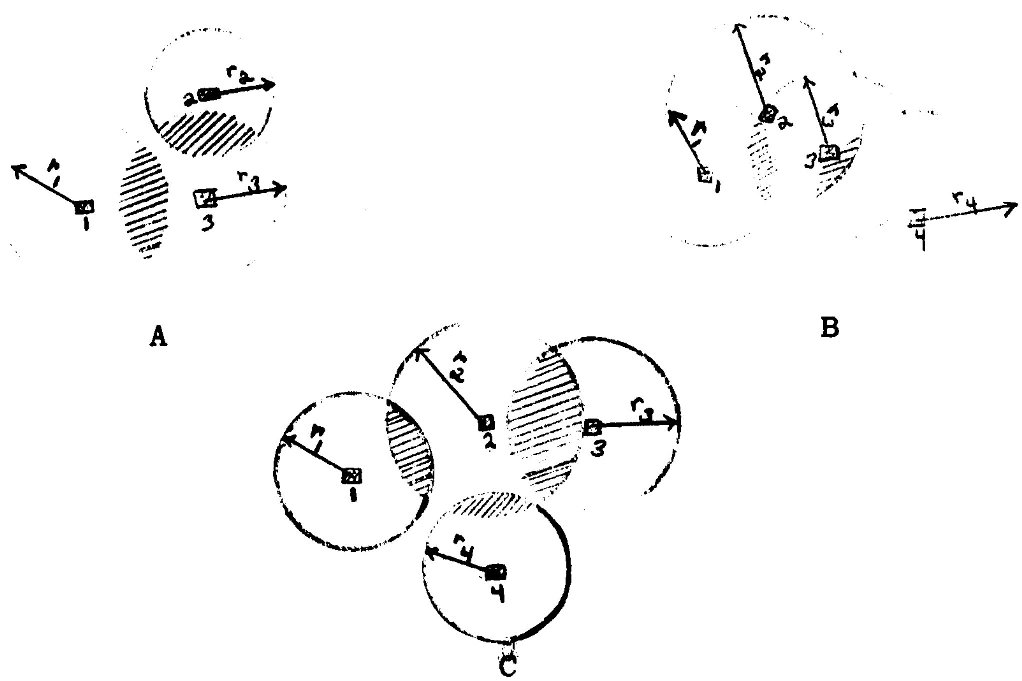

Figure 3

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It is most convenient to establish the value of r_i on a graph, (Figure 4). The parameters established will be: the requisite probability of target destruction $P_{i\,\underline{tr}}$, and the radius of the zone of destruction of the i-th element $R_{a\,i}$, expressed in Vp units. By reading from the graph, the value r_{vi} will also be expressed in units of Vp. To determine r_i it is necessary to multiply r_{vi} by Vp, i.e.,

$$r_i = r_{vi} Vp. \qquad (3)$$

Thus, after finding the r_i for each target element, the area of possible positions for the aiming point (points) is determined, in which the assigned possibility of carrying out the planned firing task is ensured. It is then necessary, within the area that has been found, to select the optimum aiming point, which ensures the maximum mathematical expectancy of the destroyed portion of the target.

The mathematical expectancy of the destroyed portion of the target (in the task under consideration, this will be the mathematical expectancy of the relative number of target elements destroyed) can be defined as the sum of the probabilities of destruction of elements of the target divided by the total number of elements:

$$M = \frac{1}{n}\sum_{i=1}^{n} P_i; \qquad (4)$$

where n - is the number of elements:
P_i - is the probability of destruction of the i-th element.

Consequently, it is necessary to find the point at which the sum of the probabilities of destruction of separate elements will be the maximum.

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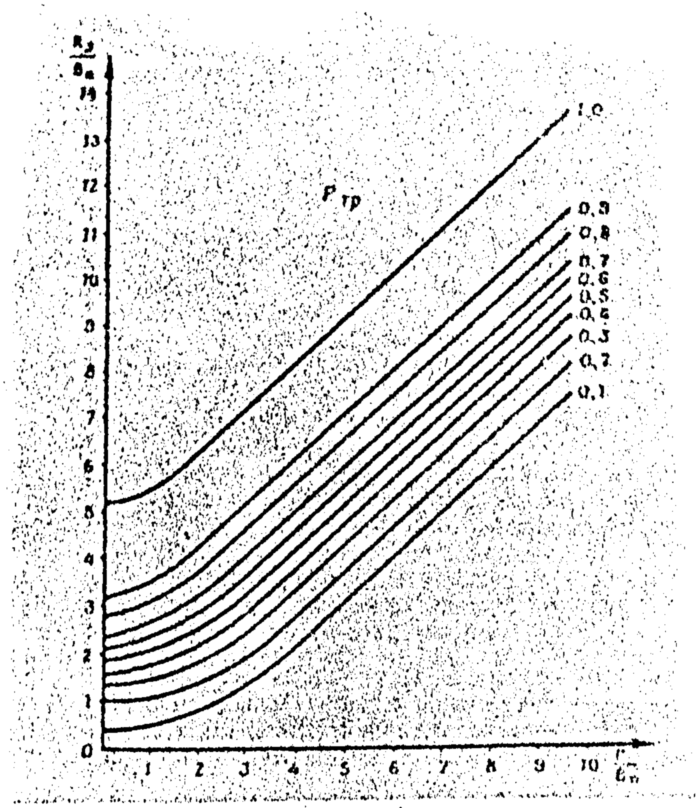

Figure 4

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Let us first examine a target consisting of two elements (Figure 5), and let us assume that the aiming point Ts is selected in the center of the area of possible aiming point locations. Obviously, by moving the aiming point toward one of the elements, for example the first, the probability of destruction of the first element grows, while that of the second diminishes.

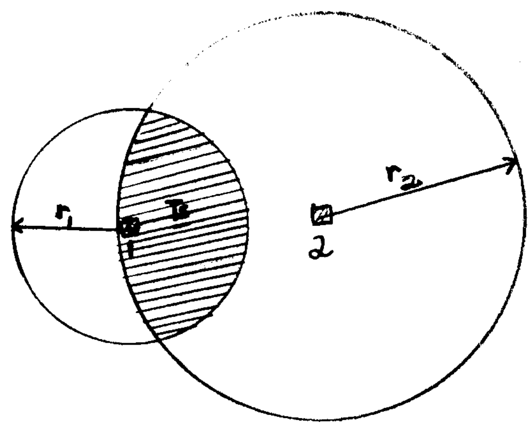

Figure 5

Figure 6 graphically shows the change in the probability of destruction with an increase in the distance between elements of the target and the aiming point. From the graph it is clear, that if the initial probability (in the center of the area) is greater than 0.5, that by decreasing the distance in question to some degree, then the probability is increased to a lesser degree than it is decreased by increasing the distance between the aiming point and elements by the same magnitude. Actually, with an initial probability of 0.7, by moving the aiming point toward the element by one Vp, the probability of destruction increases by 0.17, as is seen from the graph; but by moving the aiming point away by one Vp - it decreases by 0.30.

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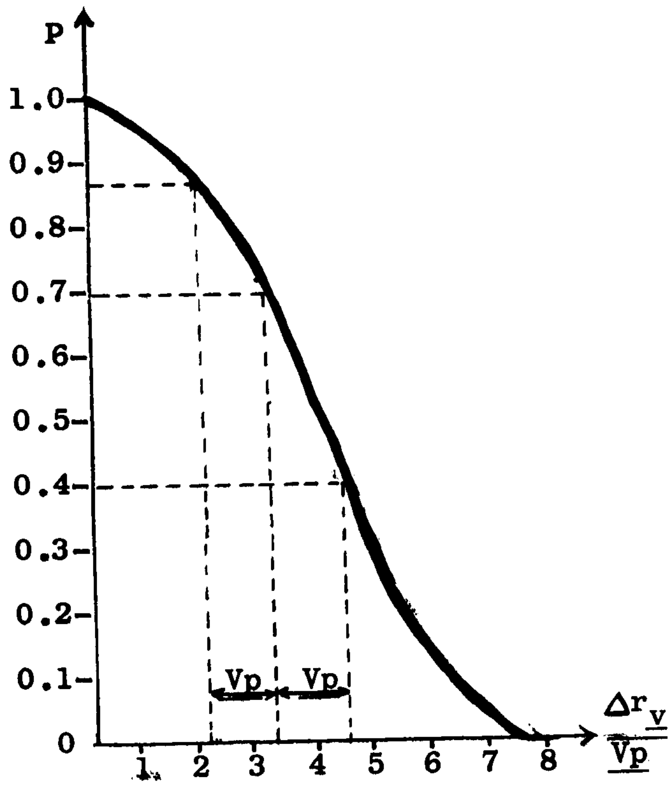

Figure 6

Thus, if we move the point of aim toward the first element, then the probability of its destruction grows to a lesser degree than the probable destruction of the second element is decreased. Therefore, the sum of the probabilities of destruction of both elements decreases. From this follows the conclusion that, for two elements, the optimum aiming point is located in the center of the area of possible aiming point location.

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In selecting the aiming point, in case of necessity, the relative importance of elements of the target can be taken into account by assigning them a higher level of $P_{i\,\underline{tr}}$ for the more important elements. If the coefficients of importance of the elements of the target are found, then the following formula can be used for determining the $P_{i\,\underline{tr}}$

$$P_{i\,\underline{tr}} = a_i \frac{\sum_{i=1}^{n} P_{i\,\underline{tr}}}{\sum_{i=1}^{n} a_i},$$

where a_i - is the coefficient of importance of an element of the target;

$P_{i\,\underline{tr}}$ - is the probable destruction of the element, assigned without consideration of its importance.

The case examined by us is when the initial probability of destruction of the element is less than 0.5. In practice, this case actually has significance, as the assigned certainty of destruction of the target must be sufficiently high.

If the target consists of more than two elements, then, generally, moving the point of aim toward one of the elements will increase the distance between the point of aim and the remaining elements, which will result in a reduction in the sum of the probabilities of destruction of the elements.

Depending on the actual location of elements of the target, the given rule can in some cases be violated. This will occur in the case when the target elements are positioned in a line by the extent of the radii of their zones of destruction (Figure 7). However, in practice, such targets are very rarely encountered. Furthermore, the deflection of the aiming point locations from the optimum, under these conditions, as the calculations show, brings a very small reduction in the amount of mathematical expectancy of the destroyed portion of the target.

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Proceeding from the foregoing one can draw a general conclusion: AFTER LOCATING THE AREA OF THE AIMING POINT'S POSSIBLE POSITIONS, THE AIMING POINT MUST BE DEFINED AS THE CENTER OF THIS AREA; IN THE CASE WHEN THE AREA OF POSSIBLE LOCATION OF POINTS OF AIM CONSISTS OF SEPARATE SECTORS, THE POINTS OF AIM MUST BE DEFINED AS THE CENTERS OF THESE SECTORS.

Within the target may be included especially durable elements, for which the condition $P_i \geqslant P_{i\ \underline{tr}}$ is not fulfilled with the given yield of the combat charge. In this case we apply $r_i = 0$, and designate the especially durable element as the point of aim, if it is within the area of possible points of aim for the remaining elements, or else we designate a second point of aim (and increase the expenditure of missiles), if this element is located outside the area of possible location of points of aim for the remaining elements. This second point of aim will, in fact, be the especially durable element.

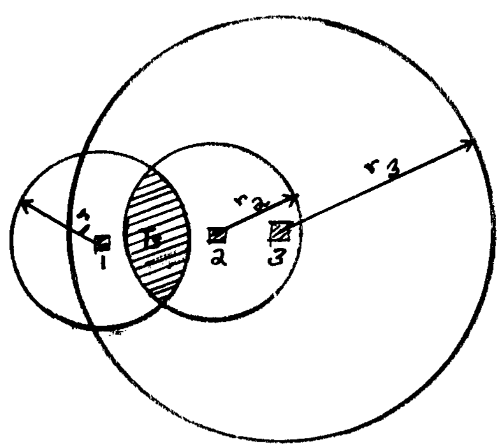

Figure 7

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In the presence of several such elements, the expenditure of missiles is allocated according to the number of elements; and the points of aim are selected in the centers of the elements.

We will return to the question of determining the requisite probability of destruction of separate elements $P_{i\,\underline{tr}}$.

In the assignment of a fire mission, either the mathematical expectancy of the destroyed part of the target $M_{\underline{tr}}$, or the probability of destruction of the whole target $P_{\underline{tr}}$ can be given.

If assigned the mathematical expectancy of the destroyed portion of the target, then one can examine it as the median probability of destruction of the separate elements. Then:

$$P_{i\,\underline{tr}} = M_{\underline{tr}}. \qquad (5)$$

If given the probability of destruction of the entire target, then in determining the required probability of destruction of the elements, it is necessary to proceed from the nature of the target. In this, it is expedient to divide all targets into three groups:

1st group - targets, for the destruction of which it is necessary to destroy all elements;

2nd group - targets, which are destroyed by the destruction of several elements, differing in each separate case;

3rd group - targets, which are destroyed by the destruction of even one element.

For targets of the first group, recognizing that the connection between the instances of destruction of separate elements in the employment of powerful charges is extremely close, the probability of destroying a separate element can almost be considered equal to the probability of destruction of the whole target. Then the required probability of destruction of a separate element is determined by the formula:

$$P_{i\,\underline{tr}} = P_{\underline{tr}}. \qquad (6)$$

For targets of the second and third groups it is necessary to establish the connection between the probability of destruction of the target and the mathematical expectancy of destruction of a portion of the target. It is easy to establish this connection, knowing the law of target destruction. The subsequent established mathematical expectancy is considered the median probability of destruction of separate elements and the required probability of destruction of an element is determined by equation (5).

The most complicated question is establishment of the law of target destruction. In the works of Colonel A.A. Chervonyy are presented and established possible hypotheses of types of laws of destruction of large targets, which permit us to reach a solution of the tasks which interest us.

For targets of the second group the most basic is the normal law of target destruction

$$P = F_{\tau}(10M - 5), \qquad (7)$$

where F_{τ} - is the tabular function F (x);
M - the mathematical expectancy of the destroyed portion of the target.

Knowing $P_{\underline{tr}}$ from the table of functions F (x) we can find $M_{\underline{tr}}$ and thereafter by the equation (5), the $P_{i\,\underline{tr}}$.

On the basis of the formula (7) a table has been compiled for the values of the required probability of destruction of an element of the target $P_{i\,tr}$, depending on the assigned probability of destruction ~~of~~ the entire target.

This table is given below.

The Value of $P_{i\ \underline{tr}}$ for Targets of the Second Group

$P_{\underline{tr}}$	0.9	0.8	0.7	0.6	0.5
$P_{\underline{tr}}$	0.70	0.62	0.58	0.54	0.50

Table 1

For targets of the third group, the most expedient is acceptance of the hypotheses of the normal kind of function for assessment of the destroyed portion of the target:

$$F\ (\xi\ ) = F_{\tau}\left(\frac{\xi - M}{E\xi}\right), \qquad (8)$$

where ξ - is the destroyed part of the target;
M - the mathematical expectancy of the destroyed portion of the target;
$E\xi$ - the median deflection of the destroyed portion of the target.

For finding the unknowns M and $E\xi$ it is necessary to equate the function (8) at two points, at which its value is known. As the first point we can take $\xi i=1$, where the function (8) for physical considerations is practically equal to 1. Accepting $F(\xi \leqslant 1) = 0.9996$, we get,

$$E\xi = 0.2 - 0.2M. \qquad (9)$$

As a second point we take the point $\xi 2 = \frac{1}{n}$, where n - is the number of elements comprising the target. If the target is destroyed by putting just one element out of action, then, evidently, the minimal destroyed portion of the target, with the assigned probability $P_{\underline{tr}}$, is equal to $\frac{1}{n}$: Then

$$F(\xi \leqslant \frac{1}{n}) = 1 - P_{\underline{tr}}. \qquad (10)$$

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Proceeding from P_{tr} according to formula (10) we determine the value ($\frac{\text{[missing]}}{n}$), then from the table for calculating the probability , we determine the value of the argument $\left(\frac{\frac{1}{n} - M}{E\xi}\right)$ and taking into account equation (9), we find M. After which we equate it to $P_{i\ tr}$.

Below is a table of values of required probability of destruction of elements, depending on the assigned probability of destruction of the target and the number of elements in a target, calculated according to formulas (9) and (10).

Values of $P_{i\ tr}$ for Targets of the Third Group

P_{tr}	Elements											
	1	2	3	4	5	6	7	8	9	10	15	100 and more
0.9	0.9	0.64	0.52	0.46	0.42	0.40	0.38	0.37	0.36	0.35	0.33	0.28
0.8	0.8	0.60	0.47	0.40	0.36	0.34	0.32	0.30	0.29	0.28	0.26	0.20
0.7	0.7	0.57	0.42	0.35	0.31	0.29	0.27	0.25	0.23	0.22	0.20	0.14
0.6	0.6	0.54	0.38	0.30	0.26	0.23	0.20	0.19	0.18	0.17	0.14	0.07
0.5	0.5	0.50	0.33	0.25	0.20	0.17	0.14	0.12	0.11	0.10	0.07	--

Table 2

Based on the above solution of the task under consideration, the following laws for selection of points of aim can be formulated:

1. On the basis of analysis of the target is determined the group to which the target belongs.

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2. Proceeding from the conditions of the planned task, the required probability of destruction of the elements of the target is determined according to formulas (5), (6) or according to Tables 1, 2 (depending on the nature of the target).

3. Determine the magnitude of $\underline{Vp}$.

4. Determine the radius of the zone of destruction for each element of the target $R_{a\,i}$.

5. Calculate the $R_{\underline{v}\,i}$ by the formula $R_{\underline{v}\,i} = \frac{R_{a\,i}\,1}{\underline{Vp}}$.

6. From $R_{v\,i}$ and $P_{i\,tr}$ according to the graph (Figure 4), determine the $\bar{r}_{\underline{v}i}$ for each element of the target.

7. Calculate r_i.

8. On the plan of the target, from the center of each element, draw the circumferences of the corresponding radii, r_i.

9. In the overlapping area of all the circles, find its center and accept it as the point of aim.

10. If the area consists of separate sectors, then designate the expenditure of missiles by the number of sectors and select the center of the sectors as the point of aim. The center of the area is determined visually.

It should be noted that in many cases it is expedient to make a graphic layout, not for all elements (installations) of a target, but only for the basic and important ones. This decreases the volume of work considerably.

The proposed graphic method for selection of points of aim for launching ballistic missiles against heterogeneous targets is simple and at the same time ensures sufficient accuracy in practice.

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In conclusion let us examine the proposed method on a concrete example.

Example. Target - Brise-Norton Air Base. The schematic plan of the base is presented below, in Figure 8. The assigned probability of destruction of the target $P_{tr} = 0.9$ with a trotyl equivalent of 8 = 150 kilotons and a characteristic of dispersion of $\underline{Vd} = 1.4$ km; $\underline{Vb} = 1$ km.

Select a point of aim.

The solution.

1. Determine the vulnerable elements of the target and their corresponding radii of destruction:

--the aircraft parking aprons 1, 2, 3; $R_{a1} = R_{a2} = R_{a3} = 4.3$ km;

--the command-dispatch point 4; $R_{a4} = 3.6$ km;

--the living quarters 5; $R_{a5} = 3.6$ km.

2. We determine the $\underline{Vp}$.

$$\underline{Vp} = \frac{\underline{Vd} + \underline{Vb}}{2} = \frac{1.4 + 1}{2} = 1.2 \text{ km.}$$

3. We determine the radii of the zones of destruction in units of $\underline{Vp}$.

$$R_{\underline{v}1} = R_{\underline{v}2} = R_{\underline{v}3} = 3.5; \quad R_{\underline{v}4} = R_{\underline{v}5} = 3.$$

4. Applying the law of target destruction normally (a target of the second group), in Table 1 we determine the $P_{i\,tr}$, using the graph in Figure 4 - we get the $r_{\underline{v}i}$ and calculate these values in kilometers.

$$r_{\underline{v}1} = r_{\underline{v}2} = r_{\underline{v}3} = 2.4; \quad r_{\underline{v}4} = r_{\underline{v}5} = 1.7;$$

$$r_1 = r_2 = r_3 = 2.9 \text{ km}; \quad r_4 = r_5 = 2 \text{ km}.$$

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5. On the plan of the target from the center of each installation we draw a circle of corresponding radii and get the area of possible location of points of aim. On Figure 8 this area is shaded from within.

6. The center of this given area is selected as the point of aim Ts (Figure 8).

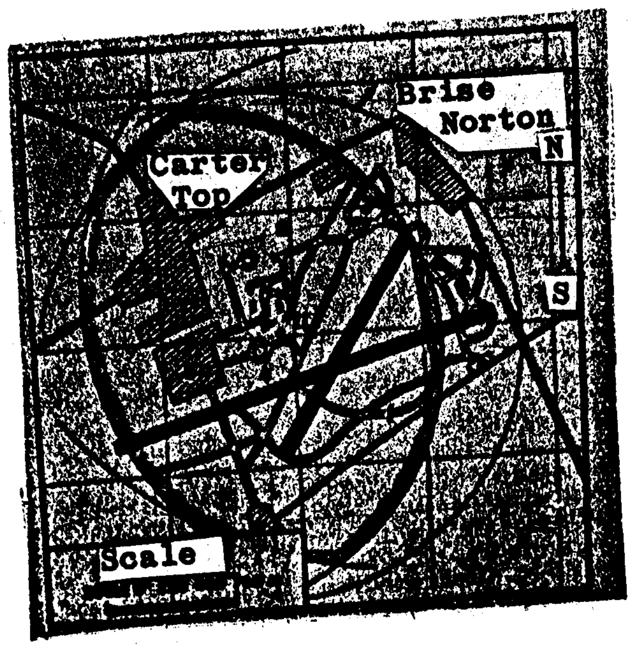

Figure 8

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In the example, such elements as the runways were not included in the target. These elements are especially durable, and their destruction requires the expenditure of charges of large yield. If, as vulnerable elements, in the conditions of the example we include the runways, then for them $r_i = 0$; and the point of aim must be located on the runway. It is clear that this will be the juncture of the runways, which does not go outside of the limits of the area of possible locations of the points of aim for separate elements.